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COMMITTEE ON THE PEACEFUL USES
OF OUTER SPACE

SCIENTIFIC AND TECHNICAL PRESENTATIONS TO THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE

Report by the Secretariat

INTRODUCTION

1. During the thirtieth session of the Scientific and Technical Subcommittee, the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU) and the International Astronautical Federation (IAF), in liaison with member States, organized a symposium on the theme "Space-based Communications: Global Systems and New Services". The symposium was organized in accordance with the recommendations of the Subcommittee at its twenty-ninth session, in 1992, that the theme fixed for special attention at the 1993 session be "Space-based communication: the expansion of current services and increased understanding of new systems and the services they will make possible" and that COSPAR and IAF be invited to arrange a symposium on the subject. The recommendations were subsequently endorsed by the Committee on the Peaceful Uses of Outer Space and by the General Assembly in its resolution 47/67 of 14 December 1992.

2. The symposium was the ninth to be organized by COSPAR and IAF during the annual meetings of the Scientific and Technical Subcommittee, with the topic for each year selected by the Subcommittee at the previous session. The symposium was held in two parts, on 16 and 17 February 1993, following the completion of debate in the afternoon meetings of the Subcommittee during the first week of its session.

3. In addition to these special presentations organized by COSPAR and IAF at the request of the Subcommittee, delegations of member States arranged a number of scientific and technical presentations by specialists in space science, technology and applications relating to various items on the agenda of the Subcommittee.

4. In order to make more widely available the information on recent developments in space science, technology and applications presented during the

symposium and the other presentations, the Secretariat has prepared a summary of that information.

SUMMARY OF PRESENTATIONS

5. The International Telecommunication Union (ITU) is the United Nations specialized agency responsible for regulating and coordinating the use of the radio-frequency spectrum and the geostationary orbit. All spacecraft that use radio communications for control or operations must conform with ITU's radio regulations. New technologies in telecommunications, including transmission techniques and computer technology, are multiplying communications capacity and services and are leading to increased competition among providers. The expanding volume and variety of services and the required inter-connectivity between systems has resulted in an urgent need for new standards. ITU efforts towards standardization aim at improving global telecommunications compatibility for computer hardware, software and consumer electronics.

6. Investment in satellite systems is growing rapidly throughout the world, and 179 notifications of new satellite communication networks were submitted to ITU in 1991 and 1992. As of 1992, more than 700 satellite networks were using the geostationary orbit, and about 100 were utilizing other orbits. In the near future, a growing number of new satellites will replace older satellites, thereby providing increased transponder capacity at lower cost. The new muti-purpose satellites will provide fixed-satellite, broadcasting and mobile services at considerably lower cost than is available today, but will require more complex and sophisticated coordination of orbital spacing and frequency assignments.

7. Future development in the fixed-satellite-service and digital technology for the 20 GHz and 30 GHz frequency bands will gradually extend the use of very small aperture terminal (VSAT) technology. Future satellites will use steerable spot-beam and multi-beam antennas, and on-board processing and switching will allow flexible uplink-downlink connections to conform efficiently to traffic requirements. Mobile communication via satellites began on a commercial basis using maritime satellites and has gradually been extended to the land mobile and aeronautical communities. Recommendations for Future Public Land Mobile Telecommunications Systems (FPLMTS) have been developed by ITU, including ground-based services for densely populated areas and satellite services for rural and isolated areas. The use of mobile satellite systems for global communications will depend on international cooperation to ensure access to such systems from different countries.

8. In the twenty-first century, digital broadcasting satellites will provide customers with high-quality sound and data broadcasting services. Digital sound broadcasting is an international cooperative development that allows the same programme to be transmitted by both satellite and terrestrial stations using the same frequency band. Reception by fixed and portable receivers, including receivers in vehicles under a variety of conditions, will be free of interference and fading. For advanced television systems, standardization and world compatibility remain important issues. Compressed digital transmission techniques are expected to replace existing national television standards and to

fit the existing 6 MHz channels in the United States and 8 MHz channels in Europe.

9. The International Telecommunications Satellite Organization (INTELSAT) was formed in 1964 as a cooperative venture among nations to provide telecommunication services to all parts of the world on a non-discriminatory basis. Although it is an international organization, INTELSAT is operated on a commercial basis according to sound financial practices. The basic framework of the organization was established and agreed to by Governments, but its management and operations have evolved to respond to market conditions and economic systems. INTELSAT currently has 125 members and has been working to adopt new technologies and to meet the challenges arising from the shift in many member States from government telecommunications systems to private, market-driven systems. In the past, only one service provider, generally a State-owned company, provided international satellite communications via INTELSAT. As economic philosophies have changed and services have been deregulated, a number of countries have implemented multiple-access arrangements, increasing the number of non-signatory users to approximately 170. The INTELSAT system currently provides instant worldwide access through 19 satellites and over 2,700 connections between Earth stations.

10. The five operating satellites of the INTELSAT VI series provide the user community with significant increases in capacity and power compared to earlier satellites, and those capabilities will be surpassed by the new INTELSAT VII satellites. In addition to developing the future INTELSAT VIII series, INTELSAT is considering a new Landmass Satellite concept to adapt to growing needs for North-South communications. Domestic, regional and international very small aperture terminal (VSAT) networks are expected to be the greatest beneficiaries of the high-power transponders on the new satellites, and the quality of television services will be improved. This quality will be evident in satellite news-gathering capabilities, multiple-access video channels, cable television using bandwidth compression and high-definition television. The INTELSAT system will also be evolving to take account of developments in the personal communications field by supporting customer mobility and the development of fly-away terminals for efficient global connectivity.

11. The International Maritime Satellite Organization (INMARSAT) currently provides communication services to more than 130 countries around the world, 64 of which are States members of INMARSAT. While the largest market for INMARSAT remains the maritime community, land mobile services are growing quickly, and INMARSAT's aeronautical service now offers full in-flight communications. The development of INMARSAT's third-generation space segment will provide more powerful and flexible satellites, each featuring one global beam and five spot beams for high spectrum efficiency. In addition, these satellites will include a navigation payload as an international civil complement to national satellite navigation systems, and L-band links allowing direct communications via satellite between mobile terminals.

12. Dramatic advances in communications technology and the shrinking size of satellite terminals have led to a number of plans for personal mobile satellite services and have prompted INMARSAT to announce its Project 21 initiative to develop a relatively inexpensive hand-held telephone for global communications via satellite. During the current planning stage, specifications are being

developed for the satellite technology, the ground network and the hand-held telephone terminals.

13. One option for global personal communications services via satellite will be low Earth orbiting (LEO) satellites connecting hand-held mobile phones to national and international networks. The need for such services was internationally recognized at the ITU World Administrative Conference in 1992 through the allocation of a new frequency band for mobile satellite services, allowing Motorola to proceed with its planning for the Iridium system. So far, investors from North, South and Central America, the Pacific Rim, Europe, the Middle East, Asia and Africa have signed subscription agreements or letters of intent.

14. The Office of Advanced Concepts and Technology of the United States National Aeronautics and Space Administration (NASA) is now developing an Advanced Communications Technology Satellite (ACTS) in order to pave the way for the next generation of operational satellites. The ACTS satellite will incorporate advanced concepts of electronically steerable spot-beam antennas, on-board processing and switching, Ka-band transmission and dynamic rain-fade compensation. The advantage of those technologies lies in higher communications capacity, greater network flexibility and the use of small and inexpensive ground stations.

15. One application of the ACTS satellite will be to provide areas stricken by natural or man-made disasters with communications capabilities through ACTS Mobile Terminals (AMT). Such a terminal can provide an immediate link between an area with a crippled communications system and the outside world through the use of very small aperture terminals with high data transmission rates for voice and video operations. An ACTS experiment is currently linking four Latin American sites to stations in the United States to demonstrate advanced telecommunications links between North and South America, including applications for telemedicine, teleradiology, medical library access and medical education.

16. Indonesia was the first developing country to launch its own domestic telecommunications satellite and is steadily developing its expertise in the use of modern telecommunications technologies. Indonesian companies are currently negotiating a contract for the 1995 launch of the third-generation PALAPA-C satellite. Another Indonesian company was formed in 1991 to enhance satellite communications services in Indonesia and other parts of South-East Asia.

17. Chinese satellite communication activities began in 1973 with the establishment of two standard-A Earth stations in Beijing and Shanghai for international communications via INTELSAT satellites. China currently operates seven standard-A Earth stations for international communications using frequency division multiple access (FDMA), time division multiple access (TDMA) and digital routing techniques to provide telephone, data and television services. Through international satellites over the Indian and Pacific oceans, China has 3,500 direct links reaching 150 countries around the globe. Satellite links have become the most important and reliable means of communications, and China plans to establish another international Earth station to serve the central and southern part of the country.

18. In China, 10 television channels and 30 radio channels are now being transmitted to about 40,000 community receiving stations with antenna apertures of 3 m to 6 m, and to over 100,000 household television receiving antennas. The satellite tele-education programme for rural areas now provides two educational channels, each with 30 hours of broadcast time per week. About 5,000 satellite educational television receiving stations and about 50,000 educational video broadcasting stations, with an annual audience of over 10 million, have been established. This application of satellite communications technology has enhanced the spread of knowledge and marks an important step forward in the use of modern technology for educational purposes in China.

19. By early 1994, China will have 12 Earth stations with 12 m to 16 m antennas for domestic satellite telecommunications services. Those 12 large domestic stations, located mainly in provincial capitals and coastal economically developed areas, together with the seven international Earth stations already in place, will form China's trunk-line satellite communications network, primarily using the international digital routing (IDR) system. The use of VSAT systems is also rapidly increasing, with 500 VSAT stations already installed.

20. The Swedish National Space Board (SNSB), under the auspices of the Ministry of Industry and Commerce, is the primary government agency in Sweden responsible for national and international space activities, including remote sensing. The launch of the Freja satellite on 6 October 1992 to conduct research on auroral and related phenomena was an important contribution to space science. This is the second satellite in the Swedish programme of small scientific satellites, the first being the Swedish-built Viking satellite launched in 1986 to study ionospheric and magnetospheric phenomena at high geomagnetic latitudes and at altitudes up to about two Earth radii. Measurements were made of electric and magnetic fields, particle distributions, plasma composition and waves, and images of auroras were acquired in the ultraviolet spectrum.

21. The Freja payload, consisting of high-resolution plasma diagnostic instruments and a fast auroral imager, includes equipment provided by Germany, Canada and the United States. Due to the high telemetry rate and the novel design of the instrumentation, which provides an order of magnitude higher temporal and spatial resolution compared to its predecessor, Freja is experimental in many ways. It is expected to improve the understanding of a number of processes and phenomena in space plasma physics.

22. Data from Freja are received at the European Sounding Rocket Launching Range (Esrange) in Kiruna, Sweden, and at Prince Albert Satellite Station, Saskatchewan, Canada. Commands for transmitting data and for switching experiments on and off are sent from Esrange, with a stored-command capability to allow operation over Canada. Full-scale scientific data collection began in late october 1992 and is scheduled to continue until early spring 1994. The next Swedish scientific satellite, called Odin, will be devoted to spectroscopic studies at sub-millimetre wavelengths of astronomical objects and processes in the Earth atmosphere. Odin is being planned as a multilateral mission to be launched in the 1996-1997 time frame.

23. During the early years of human space flight, life science studies concentrated on determining the physical needs of astronauts, and very little attention was focused on behavioural adaptation to reduced gravity or on the

psychological or social adjustments of crews to space flight. The importance of human factors in operational systems has been demonstrated in fields such as aviation and the nuclear power industry where serious and even catastrophic accidents have occurred due to lack of attention to human factors issues. As longer-duration space flights are planned, human factors become critical to the success of the missions. The Space Human Factors Program of NASA, part of its Life Sciences Division, was established to address those issues. The mission of the Space Human Factors Program is to develop the knowledge base required to understand the basic mechanisms underlying behavioural adaptation to space flight and the capabilities and limitations of crews in the unique conditions that will be encountered during future missions.

24. In order to address these issues, the NASA Space Human Factors Program conducts basic and operational research in ground-based laboratories, simulations and analogue environments, as well as during space flights. Ground-based research is conducted at NASA centres and at universities and research laboratories across the United States. In particular, the NASA Johnson Space Center in Houston, Texas, and the Ames Research Center at Moffett Field, California, have unique facilities for behaviour and performance research, including full-motion aircraft simulators, aircraft for parabolic flights providing brief periods of weightlessness and neutral buoyancy tanks.

25. The NASA Space Human Factors Program is developing a strong international component. Cooperative programmes for research in behaviour and performance have been established with the French Centre National d'Etudes Spatiales (CNES), the German Agentur für Raumfahrtangelegenheiten (DARA), the European Space Agency (ESA), the Canadian Space Agency (CSA), the Russian Space Agency (RSA), and the National Space Development Agency (NASDA) of Japan.

26. Several space flight activities are currently under way or planned for national and international research in crew behaviour and performance. Assessment of human factors and crew performance during Space Shuttle missions began with the first dedicated Spacelab Life Sciences mission (SLS-1) in 1991 and will continue on future Shuttle missions. A mental workload and performance experiment was conducted in January 1992 on board the International Microgravity Laboratory (IML-1) mission. On the Second Spacelab Life Sciences mission (SLS-2), which will be flown later in 1993, a human factors experiment using expert systems will be performed. Human workload, performance, sleep and circadian rhythm will be comprehensively studied during the third Spacelab Life Sciences mission (SLS-3), to be flown in 1996. As a part of the flight activities, NASA and the German space agency DARA will conduct joint research. The Rhesus Research Facility, proposed for SLS-3 and SLS-4, will examine the effects of microgravity and other space variables on primate behaviour. NASA is also discussing potential cooperation with the Russian Federation on the Mir Space Station in the areas of crew selection, training and performance.

27. Concerning the operational performance of space crews, research is being conducted on sleep, work performance, and circadian rhythms, as well as the fluctuations in various physiological and psychological functions with periods of about 24 hours. A common short-term disturbance of circadian rhythm is the jet lag that affects virtually all of the approximately 60 million people who travel across time zones each year. At Harvard University, Cambridge, Massachusetts, very bright (10,000 lux) light is being used to reset the human

circadian clock. Shuttle astronauts have been exposed to programmed episodes of bright light at night prior to launch to facilitate their adaptation to the work schedule required for night launches.

28. The interaction of crews in space is critical to mission success. Research on the factors that contribute to individual and group cohesion and performance in space is being done at the University of Texas. This research focuses on individual personality and group characteristics related to task performance in order to develop more effective selection and training procedures for specific tasks. The results have already been applied to several ground settings, particularly those involving high-stress conditions. Technologies have been adapted and used by the United States Federal Aviation Administration, international airlines, the medical profession and other demanding professions to enhance team training and performance.

29. At NASA Ames Research Center, research is conducted on crew communication and coordination with the goal of enhancing the performance of teams in space. This research uses real working groups in their natural environments, including air crews, undersea teams and mountaineering teams, and has correlated communication patterns and team performance. These processes can then be incorporated into training procedures which will be used to increase group productivity and to reduce human error in high-stress environments. During space flights with international crews, many anecdotal situations have revealed that language problems and multicultural factors may have a significant impact on group dynamics among the crew. Astronaut data are used at the NASA Houston Space Center to develop a knowledge base for cross-cultural factors that affect group cohesion and performance in space. These studies not only help in the selection and training of international space crews, but will also help to deal with cultural differences and minimize problems in small group interactions in confined, isolated environments, including scientific stations at sea, in the polar regions and in deserts.

30. In the field of human/machine interaction, research being performed at the NASA Johnson Space Center focuses on the design of a computer-based medical-decision support system to be used for remote medical care by both physicians and non-physicians during extended-duration space missions. This programme will help improve health care delivery in space. The provision of medical information via satellite to aid in diagnosis and treatment could also lead to improved health care delivery in remote areas of the world where traditional medical care facilities or physicians are not available.

31. On the question of the space environment, studies of the long-term evolution of space debris have shown that without changes to the way space missions are performed, regions of near Earth space could eventually become so cluttered by debris that routine space operations will be impossible. The amount of debris can be controlled in one of two ways: debris prevention or debris removal. Debris prevention measures currently being applied include technological innovations to reduce the number of non-functional objects such as shields and deployment devices released into orbit and procedures to eliminate residual propellants from upper stages. All Ariane upper stages, from flight number 60 onward, will be vented. In the case of the United States Delta rocket, the residual second-stage fuel is burned to depletion following deployment of the payload and execution of a manoeuvre to avoid a collision. A

similar procedure had been used for the upper stage of the Chinese Long March launch vehicle and the Japanese H-1 second stage and is planned for the new Japanese H-2 vehicle.

32. Another technique for reducing the risk of collisions with space debris is boosting a satellite into a disposal orbit at the end of its operating life. That method is at present the only practical way to reduce the risk of collisions in the geostationary orbit. The procedure has been performed over 60 times, although some manoeuvres could not be completed due to underestimation of the remaining propellant, leaving the inert satellites in slightly elliptical orbits that still pass through the geostationary orbit. Although recent theoretical studies have indicated that an increase in orbital altitude of 300 km to 400 km is needed to ensure against collisions, the average re-boost altitude increase to date has been about 250 km. A multiple-burn strategy could be adopted to take into account uncertainties in propellant estimates.

33. A more detailed summary of the scientific and technical presentations during the session of the Scientific and Technical Subcommittee is contained in the annex to the present report. Because of the technical character of the material, the annex appears in the language of preparation (English) only. A list of the presentations and the speakers is contained in the appendix to the annex.

Annex

SUMMARY OF THE SCIENTIFIC AND TECHNICAL PRESENTATIONS IN THE SCIENTIFIC AND TECHNICAL SUBCOMMITTEE

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I. SYMPOSIUM ON SPACE-BASED COMMUNICATIONS

A. The changing environment for global communications

1. After 35 years of space activities, space technology and satellite communications are today essential elements of global commerce and development, as well as vital tools of science, peace-keeping and disaster mitigation. The United Nations system plays an important role in increasing international cooperation and in promoting and coordinating the use of space for the benefit of all humankind.

2. The International Telecommunications Union (ITU) is the specialized agency within the United Nations system with responsibility for regulating and coordinating the use of the radio-frequency spectrum and the geostationary orbit. Space activities, virtually all of which use radio for spacecraft control and for data transmission, must therefore conform with ITU's radio regulations.

3. In the ever-changing environment of telecommunications, government services and monopolies in many countries are currently being transformed to competitive communication enterprises and national markets for communication services are becoming increasingly deregulated. As a result, communications are being more actively marketed, and users, especially large users, can obtain new services at lower costs.

4. New transmission techniques and computer technologies applied to telecommunications are multiplying international communications capacity, providing faster connections and increasing competition among service providers. The increasing volume and variety of international communications is making the need for international standards more urgent. ITU is therefore promoting the adoption of international standards to ensure global telecommunications compatibility for all systems, including computer hardware, software and consumer electronics.

5. International investment in satellite systems is growing rapidly. As of 1992, more than 700 satellite networks were using geostationary satellites, and about 100 more were using non-geostationary orbits. In 1991 and 1992, ITU received notifications for 179 new satellite communications networks. In the near future, new satellites launched to replace existing spacecraft will provide increased transponder capacity at lower cost, including capacity for satellite broadcasting and mobile service as well as conventional telecommunications services. Multi-purpose satellites, while offering greater service at lower cost, will require more complex and sophisticated coordination to meet the different constraints of orbital spacing and frequency coordination in the different services.

6. The introduction of new technologies is sustaining the competitiveness of satellites in the face of cost reductions in land-lines due to the introduction of high-capacity fibre optic cables. Experience has shown that satellite links are important back-ups in cases of failure of submarine cables, and some satellites are being designed with high-capacity transponders particularly suitable for taking over optical cable traffic in case of need.

7. An area of rapid growth in satellite communications is the use of very small aperture terminals (VSATs), which are relatively low priced and easy to install and operate. VSAT systems currently can provide low-volume digital communications for private data networks and rural telephone, fax and

electronic mail services. Increasing satellite power as well as developments in digital technology for the 20 GHz and 30 GHz radio-frequency bands will extend the applications of VSATs. Future satellites will use steerable spot-beam and multi-beam antennas and onboard signal processing and switching to provide flexible and efficient matching of satellite capacity to traffic requirements.

8. Mobile satellite communications began on a commercial basis with maritime services and have gradually been extended to land-mobile and aeronautical users. Today a suitcase-sized portable terminal can provide voice and data links, and smaller systems such as hand-held personal telephones and paging systems are being developed.

9. ITU has developed a set of recommendations for a Future Public Land Mobile Telecommunications Systems (FPLTS), including terrestrial links for densely populated areas and satellite links for rural and isolated areas. The use of satellite systems for international mobile communications will depend on international cooperation to ensure the compatibility of signals from different national systems.

10. In the 21st century, digital broadcasting satellites will provide customers with high quality radio broadcasting and data distribution services. Digital sound broadcasting techniques are being developed to allow the same programme to be transmitted by satellite and by terrestrial stations and relays using the same frequency. Reception by fixed and portable receivers, including receivers in vehicles under a variety of conditions, will be free of interference and fading.

11. The development of international standards to ensure compatibility of advanced, high-resolution television signals remains an important issue. Standards for digital television signals will be adopted, and such signals are expected to gradually replace existing analogue signals. Signal compression techniques will be used to enable the new signals to fit within the existing 6 MHz channels in the United States and the 8 MHz channels in Europe.

12. Global positioning and navigation satellites are being used by more and more users throughout the world for both land and water navigation. The United States Global Positioning System (GPS) provides accurate three-dimensional position information together with a precise time reference anywhere on or near the surface of the earth. Small, low-cost, hand-held terminals offer an accuracy of about 100 m.

13. To meet future challenges and needs in telecommunications an ITU Plenipotentiary Conference held in December 1992 adopted a new constitution and convention for the Union and approved a fundamental restructuring of the secretariat in order to respond more effectively to the new requirements for radio and telecommunication standardization and development.

B. The changing dynamics of INTELSAT

14. The International Telecommunication Satellite Organization (INTELSAT) was formed in 1964 as a cooperative venture among nations to provide satellite telecommunication services to all parts of the world on a non-discriminatory basis. Although it is an international organization, INTELSAT is operated on a commercial basis. The basic framework of this organization was established and agreed

to by governments, but its management and operations have evolved in response to changing market conditions and economic structures. INTELSAT currently has 125 members.

15. INTELSAT has continuously adopted new technologies to meet the requirements of member States for expanded, improved and new services, In recent years, many of the member States have been shifting from government controlled telecommunications agencies to market-oriented enterprises through the privatization of the state-owned agency. While INTELSAT member States have only one signatory agency, which represents the State in policy-making bodies, there is no limit to the number of entities that may have access to the system.

16. Access to the INTELSAT system by private communications agencies is left to individual countries and is handled in different ways by Member States. In the past, in most States, only one communications agency, generally a state-owned company, was authorized to offer international communications services via INTELSAT satellites. As economic philosophies have changed, leading to deregulation, a number of countries have implemented multiple access arrangements, increasing the number of non-signatory users to approximately 170.

17. INTELSAT planning is now focusing on increasing the efficiency of operations and reducing operating expenses, while balancing the needs of the largest and smallest users. INTELSAT satellites, originally designed primarily for handling bulk telephone traffic, have evolved towards digital video, voice and data services designed to meet the needs of large and small users in big cities and remote areas.

18. The five operating satellites of the INTELSAT VI series have significantly more capacity and power than previous series, and those capabilities will be surpassed by the new INTELSAT VII satellites soon to be launched. For the future, INTELSAT will be developing not only the INTELSAT VIII series, but also a new Landmass Satellite concept designed particularly to meet the growing needs for North-South communications.

19. National, regional and international VSAT networks are expected to be the greatest beneficiaries of the high power transponders on the new generation of INTELSAT satellites. Improved services for video transmissions will also support expanding use of satellites for news gathering, multiple-access video channels, more efficient television distribution using signal compression techniques, and high-definition television transmissions. Low-cost, small mobile or "fly-away" terminals will make global satellite links increasingly available for temporary or emergency use.

20. With 28 years of experience, INTELSAT is now providing satellite communication services worldwide through 19 satellites and over 2700 station-to-station links. To meet the evolving telecommunication requirements of a changing world, INTELSAT will continue to develop and use the latest communication technologies in order to reduce costs and provide new services.

C. The changing dynamics of INMARSAT

21. The systems and services offered by INMARSAT currently are currently used by more than 130 countries around the world, of which 64 are member States of INMARSAT. While the largest

market for INMARSAT services still remains the maritime community, land-mobile services are growing quickly, and INMARSAT's aeronautical service now offers full in-flight communications.

22. With the second generation of INMARSAT satellites currently coming into service, the number of users of the system has increased rapidly over the past several years, particularly in the Atlantic and Indian ocean regions. The new satellites provide more than double the communications capacity of the first-generation satellites, which are being shifted to spare or standby status.

23. The third-generation satellites, now in the design stage, will be yet more powerful and flexible, each featuring one global beam and five spot beams in order to make efficient use of the radio-frequency spectrum. Those satellites will also carry a navigation payload, as an international civil complement to national satellite navigation systems, and an L-band/L-band link allowing direct communications between mobile terminals, which currently need to be relayed through a coast earth station.

24. Dramatic advances in communications technology and the shrinking size of satellite terminals have prompted INMARSAT to develop the Project 21 initiative for the development of a hand-held, satellite-linked telephone for use anywhere in the world. The current planning stage of that project involves the definition of an advanced satellite design, a ground control and relay network, and specifications for the hand-held telephone terminals. Very preliminary estimates suggest that the telephone might cost about $1500 and about $2 per minute for calls. The primary market would probably be international businessmen or officials.

25. These INMARSAT initiatives will speed the introduction of new services using new types of mobile satellite terminals that are smaller, more flexible and cheaper to buy and to use. Such technological advancements will bring the benefits of mobile satellite technology to many more people than has previously been possible.

D. Global personal communications services

26. With currently available technology, global satellite communications systems are feasible from an engineering standpoint, but financial, social and practical factors limit the use of such systems to a small portion of the five billion people around the globe. The challenge is to overcome the economic limitations, political barriers, and language and cultural differences that limit the ability of people to communicate with each other. Proposed new systems for global personal communications services (PCS) will open up new possibilities for exchange of information, enabling medical advice to reach rural areas, ensuring information flow to the smallest schools in remote villages, and facilitating disaster warning, monitoring and mitigation.

27. In the United States over the past few years, there has been a remarkable growth in telephone technology, including cordless home telephones and urban cellular telephones. In 1993, the number of United States cellular telephone subscribers surpassed 10 million, with an investment of over $10 billion and the creation of 100,000 jobs.

28. Another development in portable telephone applications is in the area of modem-based data transmission, allowing people to work away from their offices without losing touch or access to

information. The ability to continuously send and receive digital data will ensure that the connection to the office is routine and does not require special arrangements. "Data only" communication services will enable people to receive messages, update their schedule changes and send and receive information through personal notebook and pocket computers.

29. The globalization of industry and commerce, deregulation of communications, and open markets will present major opportunities for new global personal communication services. An example of the potential for expansion can be seen in the state of international telephone service in the former Soviet Union, where last year there were 55 outgoing public international telephone circuits to serve nearly 250 million people. A single satellite designed for personal communication services could immediately offer direct-dial services to the entire world with 2000 circuits.

30. One approach to personal communication services would use low-Earth-orbiting (LEO) satellites with portable hand-held telephones to connect remote areas around the world to the international network. The 1992 World Administrative Radio Conference of the International Telecommunications Union (ITU) provided for such services through the allocation of a new frequency band for mobile satellite services. That provision enabled the Motorola company to proceed with its development of the Iridium satellite programme. The proposed financial arrangements for Iridium will ensure that every country participating in the network will receive revenue whenever a call is placed through Iridium from or to its territory, or using a handset registered in the country, or routed through an Earth station in the country.

31. Every country will be able to participate in the Iridium programme on a variety of levels, ranging from small-scale users to major investors. So far, investors from North America, Latin America, Asia, Africa and Europe have signed subscription agreements or letters of intent.

E. Applications of satellite communications for development

32. Following the devastating earthquake in Armenia in December 1988, the United States National Aeronautics and Space Administration (NASA) provided the Soviet Union with medical advice via satellite, bringing specialized expertise to an area where communications, transportation, health care and other services had been severely damaged.

33. The participating medical institutions, located in various places in the United States and the Soviet Union, provided expertise in such fields as sanitation, preventive medicine, post-traumatic stress, rehabilitation and reconstructive medicine. During a period of three months, the cases of over 200 patients were reviewed over the satellite links, and 25 per cent of the diagnoses were changed as a result.

34. The United States Advanced Communications Technology Satellite (ACTS) is designed to demonstrate new communications technologies, including applications such as disaster mitigation and telemedicine, in order to pave the way for the next generation of commercial satellites. ACTS will use advanced techniques including electronically-hopping spot-beam antennas, onboard processing and switching, Ka-band transmission and dynamic rain-fade compensation. The advantages of those technologies include in higher communications capacity, greater network flexibility and smaller, simpler and less expensive Earth ground stations.

35. The ACTS satellite and ACTS Mobile Terminals can be used to restore communications services to areas where existing services have been destroyed. ACTS can provide an immediate link between a crippled area and the outside world through the use of a very small satellite terminal providing high data rates for voice and video transmissions.

36. Currently an ACTS experiment is being developed to link four sites in Latin America to stations in the United States in order to demonstrate applications of advanced telecommunications for telemedicine, radiology, medical library access and medical education. This and other ACTS experiments are intended to promote private sector investment and involvement, and to test and demonstrate the new technologies before their operational use.

37. The need to expand availability of quality medical care in particularly great in the developing world, where 80 per cent of the population lives in rural areas while the majority of physicians live in the cities, most often in and around the capital. Access of rural people to adequate health care facilities is often hampered by poor roads and telecommunications. Satellite communications could facilitate and enhance health care through dissemination of health information to rural areas, collection of health information from rural areas, administration and coordination of the health network, and education of health care personnel.

38. A satellite health network has been proposed for West Africa, using a small constellation of low-Earth-orbit communication satellites to link a regional medical centre with village clinics and mobile health teams. Where more economical, two-way radio-telephone would be used to link villages or mobile units to local clinics, which would be linked to the regional centre via satellite. It was estimated that ten microsatellites could be built and launched for about $21 million, while about $30 million would be required for the medical facilities and the Earth station network. Such a system could dramatically improve the access of rural people to good medical care.

39. If current trends continue, the development of satellite communications in the 21st century will be driven by the increasing internationalization of economic production and trade, by limitations on the consumption of energy and other natural resources, by an increased concern for environmental protection; and by continuing advances in electronics, computers, communications and other information technologies. To compete in a global market, it will be essential to have access to information and to efficient means for handling that information. It is estimated that the market for telecommunications and related services will exceed $1,000 billion by 2005.

40. During the first two decades of satellite communications, the technology was applied primarily for telephone circuits and television distribution. However, fibre optics technology, with its very high communications capacity is gradually replacing those applications. In the future, growing areas of satellite applications will include inter- and intra-business networking, international mobile land, sea and air communications, and global positioning and navigation systems.

41. In 1976, Indonesia became the first developing country with its own domestic communication satellite, and the Palapa satellite system and its applications for economic and social development have been steadily developed since that time. The second-generation Palapa satellites were put into operation beginning in 1983, and Indonesia is now planning for the 1995 launch of a third-generation Palapa-C satellite. The Palapa system is used for telephone, television, data and business network

communications, providing services through more than 200 Earth stations and serving areas that previously had poor and unreliable communication links with the rest of the country and the world.

F. Satellite communications in China

42. Based on 20 years of development, satellite communications technology in China is playing an important role in both international and domestic communications, including television distribution, educational television, news services and financial and administrative data networks for banks, customs and the oil and coal industries. Satellite technology has greatly improved communications facilities between China and other countries and has thereby contributed to China's rapid economic growth.

43. The Chinese satellite communications application programme was started in 1973 with the establishment of two international standard-A Earth Stations in Beijing and Shanghai. China now operates seven international standard-A earth stations, using frequency division multiple access (FDMA), time division multiple access (TDMA), and international digital routing (IDR) techniques. These stations provide international telephone, data and television services through Intelsat satellites over the Indian and Pacific Oceans, with 3,500 circuits to more than 150 countries. To further improve access to international communications services, China plans to establish another international Earth station to serve the central and southern part of the country.

44. Satellite distribution of television and radio programmes began in 1985 through a transponder leased from Intelsat. A year later the Chinese Education Television (CETV) programme was established, using satellite links, in order to expand and improve the training of teachers in basic education and to raise the general level of education. The great social and economic benefits of this educational satellite television programme have become one of the driving forces behind the rapid development that China is undergoing.

45. There are now 10 television channels and 30 radio channels being transmitted to about 40,000 receiving stations with antenna apertures of 3 m to 6 m and to over 100,000 residential television receiving stations. The satellite tele-education system for rural areas now provides two channels of educational programmes with 30 hours of broadcast time per week. Almost 5,000 educational television receiving stations and about 50,000 educational video broadcasting stations have been established, with an audience of over 10 million.

46. Five large Earth stations for domestic satellite communications, with apertures of 12 m to 16 m, were established in 1985 in Beijing, Lhasa, Urumqi, Hohhot and Guangzhou, creating a trunk-line satellite communications network. By 1994, the network will include a total of 12 such Earth stations. These 12 domestic stations, together with the seven international Earth stations, located mainly in provincial capitals and coastal economically-developed areas, will form China's trunk-line network utilizing digital routing technology.

47. The use of very small aperture terminals (VSATs) in China is rapidly growing, with 500 VSAT stations already installed. The People's Bank of China has established a satellite communication network consisting of nearly 200 terminals linking its headquarters with the main branch offices. A satellite communication network proposed by the Ministry of Trade and Economic

Relations, including voice, data, E-mail, video-text and television conferencing services will, when completed, be the biggest of its kind in China.

G. Radio Broadcasting Services for Africa

48. For decades, shortwave broadcasting has provided news, information and cultural programming, facilitating the free flow of information throughout the world. Shortwave broadcasting has been an important means by which people in different regions communicated with each another, and shortwave remains, in some cases, the medium for radio broadcasting within developing countries. Shortwave radio, however, is plagued by ionospheric interferences, spectrum crowding, poor sound quality and difficulties in tuning. Other ground-based radio systems such as medium wave, AM and FM offer better sound quality than shortwave, but are limited in coverage area and have high costs for installation and operation.

49. In developing countries, where radio remains an important form of information distribution, there is a need for improved services. The challenge is to provide better sound quality with greater coverage while reducing transmission costs. New radio technology now allows satellite radio broadcasting directly to portable radios using advanced digital modulation and coding techniques, which represent the most significant advance in radio communication in 75 years.

50. A simple, relatively inexpensive satellite can cover an entire continent with the highest quality digital radio at a transmission cost far less than any ground-based system. It is particularly attractive in developing countries, where there is a high reliance on radio and a strong demand for more coverage and higher quality reception. The main advantages of digital satellite sound broadcasting are low transmission costs for large-area coverage, a superior sound quality comparable to FM in fidelity, reliable transmission facilities, and the ability to upgrade to a compact disk sound quality.

51. This service is attractive to many types of users: national broadcasters seeking to provide cost-effective national or regional service; international programmers wishing to upgrade from shortwave; specialized programmers providing cultural, educational or health broadcasting; and commercial broadcasters. Strong support for satellite broadcasting among developing countries led to a worldwide frequency allocation of 1400 MHz for this service at the 1992 ITU World Administrative Radio Conference.

52. The WorldSpace company intends to offer digital satellite radio broadcasting services through regional satellite broadcasting systems covering the Mediterranean Basin, Africa and West Asia (AfriSpace), South America (AmeriSpace), the Caribbean (CaribSpace), and Asia and the Pacific (AsiaSpace). AfriSpace was the first company to obtain governmental approval for satellite radio broadcasting, and CaribSpace recently received a license from Trinidad and Tobago to operate a satellite system that could cover the entire Caribbean basin. The company is working with regulatory agencies in Brazil and Australia to secure approval for broadcasting in the Latin American and Asia-Pacific regions. WorldSpace will market its services through the sale or lease of channels on its first two satellites, AfriStar-1 and CaribStar-1.

53. Each regional system would consist of transmitting stations, the small satellite and the radio receivers. In the case of AfriSpace, uplink facilities in Africa, the United States and Europe would

receive programming and uplink it to the AfriStar-1 satellite for broadcasting to the African-Arabian region. The satellite would cover the region with three beams, each beam covering one-third of the entire area and providing 12 channels of FM-quality broadcasting. New radios will be needed to receive the satellite sound broadcasts because different frequencies and modulation techniques will be used. The core module of the digital Starman receiver, including the chip set and antenna, can be integrated into ordinary multi-band radios as a plug-in accessory, or can be used as a separate unit. The use of existing technology in the manufacturing of the receivers would make it suitable for assembly in developing countries. The use of solar power cells would eliminate the need for expensive batteries and allow use in regions without electricity.

54. The United States Global Positioning System (GPS) of radio navigation satellites has made important contributions to the development of technology that can be used in low-cost satellite radio receivers. GPS can be used through hand-held receivers operating at 1575 MHz and decoding about 50 bits per second (bps) of navigation information transmitted from satellites travelling across the sky. GPS receivers are available for about $500. Although the data rates for satellite radio broadcasting are at least 10,000 times higher than for GPS, the frequency bands and antenna technology are very similar. Both technologies use frequencies in the 1500 MHz region and both employ flat, microstrip patch-type antennas. The higher decoding rate required is facilitated by the greater satellite power and by the constant direction of the signal from the geostationary arc.

55. Today, there are about 100 manufacturers of GPS satellite receivers, all designed for continuous mobile reception of digital satellite signals. In addition, the INMARSAT mobile satellite communications system is used for data transmission and reception at 4800 bps to 9600 bps, and that technology will further pave the way for satellite sound broadcasting. There do not appear to be any fundamental technological barriers to continuous reception in a moving vehicle of digital satellite signals at data rates of 56 kbps to 256 kbps.

II. OTHER SCIENTIFIC AND TECHNICAL PRESENTATIONS

A. Small scientific satellites in Sweden

56. The Swedish National Space Board (SNSB), under the auspices of the Ministry of Industry and Commerce, is the central governmental agency responsible for national and international space efforts in Sweden, including all projects related to remote sensing. The Board receives funds from the Ministry of Education and Science for its research programme. The technical implementation of national space and remote sensing programmes is generally contracted by the Board on an annual basis to the state-owned Swedish Space Corporation (SSC).

57. Sweden recently launched its second satellite in the Swedish small scientific satellite programme, the Freja satellite for research on auroras and related phenomena. The first Swedish satellite, Viking, was launched in 1986 to study ionospheric and magnetospheric phenomena at high geomagnetic latitudes and at altitudes up to about two Earth radii. Simultaneous measurements were made of electric and magnetic fields, particle distributions, plasma composition and plasma waves, as well as acquiring images of aurora variations in the ultraviolet spectrum.

58. The Freja satellite was successfully launched on 6 October 1992, and its active lifetime is expected to be at least 18 months. It was put in a 601 km by 1756 km orbit at 63° inclination and with an orbital period of 108.9 minutes. Freja is 2.2 m in diameter and spins with its axis pointed toward the sun. The Freja mission is to make high-resolution measurements in the upper ionosphere and lower magnetosphere at auroral latitudes in order to continue the magnetospheric research begun by the Viking satellite. The Freja satellite is designed to study the plasma and the impact of auroral energy input on the upper ionosphere with greatly enhanced temporal and spatial resolution. Freja was launched during a period of intense solar activity, while Viking conducted its mission during a period of low solar activity. The Freja payload instruments were supplied by Sweden, Germany, Canada and the United States.

59. Data from Freja are received at the European Sounding Rocket Launching Range (ESRANGE) at Kiruna, Sweden, and at the Prince Albert Satellite Station in Saskatchewan, Canada. Commands for transmitting data and for switching experiments on and off are transmitted from ESRANGE, and the satellite has a stored-command capability for operations over Canada.

60. Full-scale scientific data collection started in late October 1992 and are scheduled to continue until the spring of 1994. Some of the scientific analysis is conducted at the Freja Interactive Science Center (FISC) at ESRANGE where scientists can interact with the satellite operators and control the satellite instruments while they are analyzing data.

61. The next planned Swedish scientific satellite, called Odin, will be devoted to spectroscopic studies at sub-millimetre wavelengths of astronomical objects and processes in the Earth atmosphere. Odin is planned as a multilateral mission to be launched in the 1996-1997 timeframe. The primary research will include studies of star formation processes, interstellar chemistry and atmospheric ozone balance. The Odin astronomical observing programme will emphasize interstellar molecular clouds in our own galaxy, but will also make observations of a few other galaxies. In the solar system, at least three comets will be observed in order to measure outgassing of water vapour, and spectral-line emissions from minor constituents will be used to study the chemistry, structure and dynamics of the atmospheres of the giant planets. Searches for outflows of gas from stars will also be conducted.

62. The Odin upper atmosphere research programme will include observations of various trace gases in the stratosphere and mesosphere. One experiment will study mechanisms responsible for ozone depletion in the "ozone hole" region and ozone dilution effects and chemistry outside the polar regions. Other ozone observations will examine the mechanisms of ozone transport between the upper and lower atmosphere. The satellite will also study the variability of mesospheric water vapour, including an assessment of the required fluxes for aerosol formation in the polar mesosphere.

63. The Swedish scientific small satellite programme has so far been very successful and has produced valuable scientific data. The low-cost approach has been based on piggy-back launch opportunities, a streamlined project organization and competitive procurement procedures.

B. Space human factors research

64. During the early years of human spaceflight, life sciences research concentrated on the physical needs of astronauts, particularly in such areas as radiation exposure and the physiological

effects of microgravity, including cardiovascular de-conditioning, muscle atrophy, loss of bone mineral content and neurovestibular, haematological, immunological and endocrinological changes. In contrast, very little attention was focused on behavioral adaptation to reduced gravity or on crews' psychological or social adjustments to space flight. Thus, the impact of the space environment on human behaviour and performance is relatively unknown.

65. However, longer duration missions by the United States and future international missions will involve sending small crews into space for extended periods. The importance of human factors in critical operations has been demonstrated in settings such as aviation and the nuclear power industry, where serious and even catastrophic accidents have occurred due to lack of attention to human factors. In order to ensure the safe and successful completion of these missions, the effects of spaceflight on human performance and behaviour must be understood.

66. Extended duration missions require a thorough understanding of behavioral adaptation to space and of conditions that enable people to live and work productively for prolonged periods in isolated, confined and dangerous environments. Such understandings are a necessary basis for designing environments, countermeasures and support systems to protect and enhance human capabilities, safety, health, and productivity. The Space Human Factors Programme of the United States National Aeronautics and Space Administration (NASA), part of its Life Sciences Division, was established to answer these questions. In addition to basic research, the Programme will develop requirements, procedures, and protocols for ensuring the well-being, safety, and productivity of crews in space, and to promote spinoffs from that research and technology to improve the quality of life on Earth.

67. Several human factors have been identified as essential to mission planning for long-duration space flights. One factor is the interaction and team performance of crew members and their ability to communicate with each other and with ground-support systems. The crew interactions will depend on cultural background, age, sex, occupation, the qualities of the leader, training procedures. In addition, operational performance will depend on workload, work schedule and sleep. Another factor is the physical environment of the spacecraft, including temperature, noise, design of work stations, availability of personal space, the use of automated systems, and the design of communication systems for rapid and accurate exchange of information. Finally, the ability of the crew to successfully carry out their assigned tasks will depend on sensory, perceptual, and cognitive capabilities that amy be affected by the space flight environment.

68. In order to study those factors, the NASA Space Human Factors Programme conducts basic and operational research in ground-based laboratories simulating aspects of the space environment, in analog environments, and during space flight. Ground-based research is conducted in particular at NASA Johnson Space Center in Houston, Texas, and Ames Research Center at Moffett Field, California, which have full-motion aircraft simulators, aircraft for parabolic flights providing brief periods of weightlessness, and a neutral-buoyancy tank.

69. The NASA Space Human Factors Programme is developing a strong international component, including plans for research in behaviour and performance in cooperation with the French Centre National d'Etudes Spatiales (CNES), the German Agentur für Raumfahrt-angelegenheiten (DARA), the European Space Agency (ESA), the Canadian Space Agency (CSA), the Russian Space Agency, and the National Space Development Agency (NASDA) of Japan. The NASA Programme also conducts

projects in cooperation with the United States Air Force, the National Institute of Mental Health, and the National Oceanic and Atmospheric Administration (NOAA).

70. A number of Space Shuttle flights have included substantial research programmes in behaviour and performance in space, beginning with the first dedicated Spacelab Life Sciences mission (SLS-1) in 1991. During the International Microgravity Laboratory (IML-1) mission in January 1992, a mental workload and performance experiment was conducted, and on the second Spacelab Life Sciences mission (SLS-2), which will be flown later in 1993, a human factors experiment in expert systems will be performed. Human workload, performance, sleep and circadian rhythm will be comprehensively studied during the third Spacelab Life Sciences mission (SLS-3), to be flown in 1996 in cooperation with the German DARA. The Rhesus Research Facility, planned for SLS-3 and SLS-4, will examine the effect of microgravity and other space variables on primate behaviour. NASA is also discussing potential cooperation with Russia on the Mir Space Station in the areas of selection, training and performance of crews.

71. The Spacelab Life Sciences (SLS-4) Shuttle mission, also called the Neurolab mission, is scheduled for flight in 1998 and will be dedicated to research on the brain and human behaviour. International partners on this mission include the space agencies of Canada (CSA), France (CNES), Germany (DARA), and Japan (NASDA) as well as ESA. The United States and many other countries have declared the 1990s the "Decade of Brain," and the Neurolab project is a key component of NASA's contribution to this activity. Neurolab will conduct a variety of studies ranging from examination of fundamental nervous system processes and mechanisms to applied research on human behavioral and neurological response and adaptation to space flight. It is anticipated that space research on the brain and behaviour will provide scientific insights and technological tools that will be useful for treating terrestrial disorders of the brain and behaviour, including brain disease, Alzheimer's disease, mental disorders, and communication and sensory disorders.

72. Certain terrestrial analogue environments are analogous in certain respects to the environments to be encountered on future space missions. Undersea habitats and Antarctic research sites, for example, can be used to study human performance in remote and isolated settings. Antarctic stations, isolated in rugged and hostile settings and requiring a high degree of self-sufficiency over long periods of time, offer an ideal setting for conducting extended-duration mission studies. Such stations will be used to study psychological countermeasures, crew coordination, group dynamics, selection and training procedures, and the relationship between stress, circadian rhythms and performance. NASA and CNES are planning a joint research project at the French Antarctic stations, culminating in a full international mission simulation. In addition, NASA and Australia are discussing joint human factors research at the Australian Antarctic stations, and NASA and NASDA are considering joint efforts using Japanese Antarctic facilities.

73. Use of underseas habitats allows researchers to investigate the effects on psychological health and group dynamics of confinement in small spaces like those of spacecraft. In addition, activities performed by deep-sea divers are similar in some respects to extravehicular activities during space missions. The use of telerobotics for conducting research from underwater stations will be useful in developing that new technology for space missions and in studying human-machine interactions for space applications. Consideration is being given to joint research between NASA and ESA in human behaviour and performance using the facilities of the Isolation Study for the European Manned Space Infrastructure (ISEMSI), and to joint research with the Russian Federation using its Bios-3 facility.

74. Disruption of the normal circadian rhythms of physiological and psychological functions affects the sleep and operational performance of space crews, as it affects the approximately 60 million people who travel across time zones each year and experience jet lag. At Harvard University, exposure to very bright light (10,000 lux) is being used to reset the human circadian clock. This procedure has been used successfully with Shuttle crews, who were exposed to bright light at night prior to launch to facilitate their adaptation to the work schedule required for the night launch. Physiological measurements and the subjective reports of the astronauts indicated that their circadian rhythms had shifted to correspond to the daytime sleep schedule required for launch.

75. Similar exposure to bright light can also be used to help reset the circadian clocks of shift workers on Earth. Hundreds of millions of people around the world are shift workers, working at night on either permanent or rotating shifts. The resulting disruption of the body's circadian rhythms can have a critical impact on worker safety and performance. Procedures to facilitate the re-synchronization of the body can improve employee health and well-being, decrease personnel turnover rates, improve worker productivity and reduce the incidence of on-the-job accidents. Similarly, those procedures can help people around the world with sleep disorders to remain alert during the day and to get a good night's sleep.

76. Researchers at the University of Texas are studying personality factors and group characteristics that affect individual and group performance in order to develop selection and training procedures. Procedures developed in that programme have already been used in a number of terrestrial situations involving activities that must be performed in unusual or high-stress conditions, such as aviation and medicine.

77. At NASA Ames Research Center, research is conducted on communication and coordination between crew members with the goal of enhancing the performance of teams in space. This research uses actual groups of workers in their natural environments (air crews, undersea teams, mountaineering teams) and has correlated communication patterns and team performance. The results of that research are currently being applied to the coordination of pre-flight ground activities for NASA space missions, as well as to underwater activities and mountain climbing. The results also have broad applications for increasing productivity and efficiency in manufacturing operations.

78. Anecdotal evidence from space flights with international crews indicates that language problems and multicultural factors can have a significant impact on crew dynamics. Such evidence is collected and studied at the NASA Houston Space Center in order to identify cross-cultural and group compatibility factors that affect performance in space. Those studies not only help in the selection and training of international space crews, but can be applied to multinational activities in confined, semi-autonomous environments such as isolated science stations at sea, in the polar regions, and in deserts.

79. At Georgia State University, an automated, computerized system for behavioral training and testing of non-human primates has been developed for use during the Spacelab SLS-3 mission in order to assess the effects of space flight on the psychomotor functioning and cognitive performance of /... rhesus monkeys. The system can also be used for ground-based research on a variety of monkey and ape species and for research with human subjects. Many laboratories around the world have adopted the computerized test system for research on ageing and cognition, Alzheimer's disease, eating disorders, mental illness and other conditions. The system is also being used to promote recovery of function in children and adults who have suffered brain damage. There are about 7 million

intellectually impaired individuals in the United states and over 100 million worldwide who could benefit from such computerized training in psychomotor coordination and cognitive functions.

80. In the field of human-machine interactions, research being performed at NASA Johnson Space Center focuses on the design of a computer program to assist in medical decision-making for use by both physicians and non-physicians during long-duration space missions. This research uses recent findings in cognitive science to improve instructions on medical procedures. That research could be used to provide access to medical information for diagnosis and treatment in remote areas of the world where medical care facilities or physicians are not available.

81. In other NASA research, computer models of the body are being developed and used to accurately represent humans performing tasks in space such as operation, maintenance and repair of equipment. Using high-fidelity animated simulations, the models provide information on the ability of a human or an object to fit into a small space or reach a piece of equipment. Comparison of computer-generated images with actual photographs taken in space has demonstrated the system's ability to realistically model space activities. Cost-benefit analyses of the system has shown that it can significantly reduce costs by eliminating the need for expensive life-size mock-ups. Computer programs developed as part of that research are now being used commercially by industries and universities. Potential applications include the design of working and living spaces and equipment to ensure that they correspond to human size, reach and flexibility.

C. Functions of the Russian Space Agency

82. The Russian Space Agency (RSA), a government agency of the Russian Federation, is an administrative body responsible for elaborating and implementing national policy on the exploration and use of outer space. The RSA, together with the Russian Academy of Sciences, the Joint Armed Forces of the Commonwealth of Independent States, and concerned ministries, departments and organizations, elaborates and submits to the Government a draft national space programme, with the financial and other resources required and a timetable for carrying out the work. The Agency participates in the creation and use of space systems, complexes and facilities in accordance with the national space programme, including military-civilian dual-use systems developed under defence contracts and space complexes for scientific research and applications.

83. The Russian Space Agency is headed by a Director General, who is appointed by the President of the Russian Federation. The Director General is supported by Deputy Directors General, appointed on the Director General's recommendation by the Government of the Russian Federation.

84. The Agency acts as general contractor in connection with the space systems, complexes and facilities that are developed for research and applications purposes as part of the national space programme, and develops, together with industrial organizations, the scientific and technical expertise required for space activities. The Agency cooperates with agencies of the other member States of the Commonwealth of Independent States and with foreign countries in the exploration and use of outer space, including the cooperative use of ground facilities. The Agency coordinates work on commercial space projects and on manned space flights, including efforts to ensure astronaut safety.

85. The Agency participates in and ensures the execution of scientific research and technological development, as well as the design and testing of space technology for applications purposes. The Agency ensures the development of advanced technologies and materials and the development and maintenance of ground experimental and test facilities for the development of space technology. The Agency procures equipment required for space research and development, while space systems required by the Ministry of Telecommunications and the Ministry of Ecology and Natural Resources are generally procured and operated directly by those ministries.

86. The Agency, together with industrial organizations and firms, provides the foundations for the development of improved launchers and is responsible for research and technical support for the conversion into satellite launch vehicles of strategic rocket systems that are to be reduced or eliminated.

87. The Agency is also responsible, together with other ministries and departments, for ensuring the fulfillment of the Russian Federation's international commitments in the area of space activity and for developing mutually beneficial cooperation with governmental and commercial organizations in other countries. The Agency is also to undertake, together with the Ministry of Foreign Affairs and other concerned ministries and departments, negotiations for the conclusion of further international agreements concerning the exploration and use of outer space. The Agency is responsible for maintaining a register of spacecraft owned by the Russian Federation and for providing the United Nations with information on spacecraft launched by the Russian Federation.

88. The Agency grants licenses for all types of activities connected with the exploration and use of outer space and with the provision of space services in the Russian Federation. The Agency maintains records of such activities, participates in the elaboration of standards for the development and exploitation of space technology, and participates in the monitoring of compliance with safety requirements, standards and regulatory provisions relating to the production, testing and exploitation of civilian space technology. The Agency formulates, together with concerned ministries and departments, draft legislation and other regulations governing activity relating to the exploration and use of outer space.

89. The Agency is responsible for ensuring that the public is kept properly informed of space activities and participates in exhibitions of launcher and other space technology and in the preparation and publication of scientific and technical literature on space matters.

D. Space debris

90. On the question of the space environment, studies of the long-term evolution of space debris have shown that without changes to the way space missions are performed, regions of near-Earth space could eventually become so cluttered by debris that routine space operations will be impossible. The amount of debris can be controlled in one of two ways: debris prevention or debris removal. Debris prevention measures currently being applied include technological innovations to reduce the number of non-functional objects such as shields and deployment devices released into orbit and procedures to eliminate residual propellants from upper stages. All Ariane upper stages, from flight number 60 onward, will be vented. In the case of the United States Delta rocket, the residual second stage fuel is burned to depletion following deployment of the payload and execution of a manoeuvre to avoid a

collision. A similar procedure had been used for the upper stage of the Chinese Long March launch vehicle and the Japanese H-1 second stage and is planned for the new Japanese H-2 vehicle.

91. Another technique for reducing the risk of collisions with space debris is boosting a satellite into a disposal orbit at the end of its operating life. That method is presently the only practical way to reduce the risk of collisions in the geostationary orbit. The procedure has been performed over 60 times, although some manoeuvres could not be completed due to underestimation of the remaining propellant, leaving the inert satellites in slightly elliptical orbits that still pass through the geostationary orbit. Although recent theoretical studies have indicated that an increase in orbital altitude of 300 km to 400 km is needed to ensure against collisions, the average re-boost altitude increase to date has been about 250 km. A multiple-burn strategy could be adopted to take into account uncertainties in propellant estimates.

Appendix

LIST OF SCIENTIFIC AND TECHNICAL PRESENTATIONS

I. SYMPOSIUM ON SPACE-BASED COMMUNICATIONS: GLOBAL SYSTEMS AND NEW SERVICES, ORGANIZED BY COSPAR AND IAF

The Symposium was co-chaired by Prof. G. Ohring, Chairman of the COSPAR Commission on Space Studies of the Earth's Surface, Meteorology and Climate, and by Mr. Dale Fester, Vice President of IAF.

"The Changing Environment for Global Communications," Mr. Richard C. Kirby, Director, International Radio Consultative Committee, ITU.

"The Changing Dynamics at INTELSAT," Mr. D. K. Sachdev, Director, Communications Engineering and System Planning, INTELSAT.

"The Changing Dynamics at INMARSAT," Mr. Jai Singh, General Manager, Project 21, INMARSAT.

"The Movement to Global Personal Communications Services," Mr. Peter Swan, Manager, Systems Engineering, Motorola.

"Disaster Mitigation: The Critical Communication Link," Mr. Ray J. Arnold, Acting Director for Commercial Innovation and Competitiveness, Office of Advanced Concepts and Technology, National Aeronautics and Space Administration (NASA), United States.

"Telemedicine for the Globe: The West African Case Study," Astronaut Mae C. Jemison, NASA, United States.

"Satellite Communications for Development," Mr. Oetarjo Diran, Deputy Chairman, National Institute of Aeronautics and Space (LAPAN), Indonesia.

"Satellite Communications in China," Prof. Yiyuan Chen, Chief Engineer, Institute of Space Technology, Ministry of Aeronautics and Space, China.

II. OTHER SCIENTIFIC AND TECHNICAL PRESENTATIONS

"Human Space Flight," Astronaut Mae C. Jemison, NASA, United States.

"Putting Humans in Space, Helping People on Earth," Dr. Janis Stoklosa, Manager, Space Human Factors Programme, NASA, United States.

"Radio Broadcasting Services for Africa: Emerging Developments," Mr. Noah Samara, Chief Executive, Afrispace.

"The Swedish Scientific Space Programme and Small Scientific Satellites," Dr. Marianne von Glehn, Swedish Space Board.

"Activities of the Russian Space Agency," Mr. V. V. Alaverdov, First Deputy Head, Russian Space Agency, Russian Federation.

"The Space Debris Issue and the Solutions Currently Being Adopted at the National Level," Mr. Hugues Laporte-Weywada, Directorate of Launchers, Centre National d'Etudes Spatiales, France.